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Climate Change Adaptation
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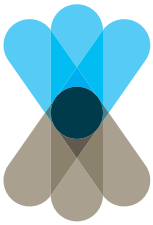
Diagnostics for Adaptation in Action: User Guide

E. Ogier, P. Leith, G. Pecl, M. Haward, J. Davidson & E. Hoshino



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Credit: Tasmanian Seafood Industry Council

Introduction

This User Guide provides an approach to climate adaptation for Australian fisheries. It has been developed by members of the Marine Adaptation Network, drawing on research and practice directed towards workable adaptation pathways that can be applied to Australian fisheries and marine resources. Such an approach has led to a structured six-stage process through which Australian fisheries scientists, fishers, fisheries managers and other key stakeholders can together define and collectively agree to adaptation pathways (see Figure 1 and Table 1). This approach centres on three core components:

Fisheries as social-ecological systems

Fisheries are complex systems. The impacts of climate change and any planned adaptations to address those impacts necessarily include social, economic, political, cultural and environmental dimensions. For this reason simplistic or "one size fits all" adaptation strategies are not likely to be effective. By including the social and ecological systems which make up a fishery as a whole, all of the variables and interactions between them which enable and constrain adaptation are included in the diagnosis (see Tables 2 and 3).

Planning to adapt

Planned adaptation is an ongoing, intentional process undertaken to address particular biophysical and socio-economic conditions, risks and uncertainties. Planned adaptation tends to be more effective when research activity is closely linked to management and practice, which is why the process described here includes fishers, fisheries scientists, managers, and other key stakeholders.

Where barriers to adaptation can be identified and agreed upon, they can be addressed through the many problem-management processes already in use: identification and prioritization of options, monitoring and evaluation of successes and failures.

Diagnosing what drives and constrains adaptation

Diagnosis, in the context of fisheries, is a process to identify how the properties and dynamics of a fishery system result in particular outcomes, and whether these are desirable or not. For example, the diagnostic approach outlined here would assist key stakeholders in a fishery to identify and, more importantly, agree upon which aspects of the fishery as a system constrain and enable strategic and tactical decision-making. These may include lack of scientific certainty about the mechanisms that lead to seasonal variability in recruitment, for instance. In other cases, it may be that an industry lacks leadership or is factionalised and cannot effectively organise.

At a minimum, the diagnostic process is likely to improve adaptive capacity generally and allows for the creation of a watching brief on potential risk factors and opportunities associated with external drivers of change.

Credit: G Pecl

Aim of the diagnostic approach

The aim of the diagnostic approach is to enable key stakeholders in a fishery to plan for climate adaptation.

The objectives of the diagnostic approach are to:

1. effectively describe the structure and function of a particular fishery as a system including its biological, ecological, economic, human, and social components, then
2. identify which aspects of this broad system can be most effectively improved through specific forms of collective action; and
3. develop a legitimate and clear plan of action as a working document that will assist with ongoing adaptation in a fishery.

The approach described here is a stepwise process that can be applied to different fisheries to plan for adaptation in the face of global change. The approach seeks to, firstly, describe system characteristics in a way that includes all relevant stakeholders' perspectives, noting that:

- in analysing biophysical risks, the approach is not oriented to making recommendations but identifying where potential risks exist, what is at stake for whom in relation to those risks; and
- in describing the social context, it is import to clarify the different positions held by stakeholders, and therefore describe - rather than resolve - conflict.

This first descriptive stage allows all stakeholders to engage in a dialogue about the system without jumping to conclusions about what needs to be done, by whom.

In later stages key stakeholders are assisted to define adaptation pathways. Adaptation pathways include ways of identifying strategic and tactical adaptation measures as well as barriers and constraints that can be more or less easily overcome.

Credit: Tasmanian Seafood Industry Council

"a diagnosis recognises opportunities and threats and from them, suitable entry points for management"

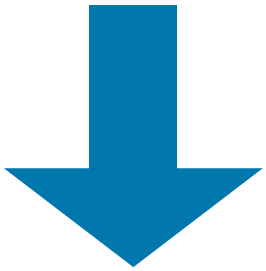
(Andrew et al. 2007, pg. 232)

Diagnostic process

Description

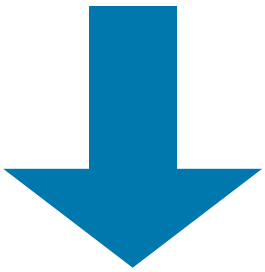
Describe the structure and function of a particular fishery as a system, including:

- biological, ecological, economic, human and social components or sub-systems
- all relevant stakeholders' perspectives



Deliberation and Diagnosis

Identify which aspects of this broad system can be most effectively improved through specific forms of collective action



Action (or purposeful non-action)

Develop a legitimate and clear plan of action as a working document that will assist with ongoing adaptation in the particular fishery, which includes:

- strategic and tactical adaptation measures
- barriers and constraints that can be more or less easily overcome

Diagnostic process

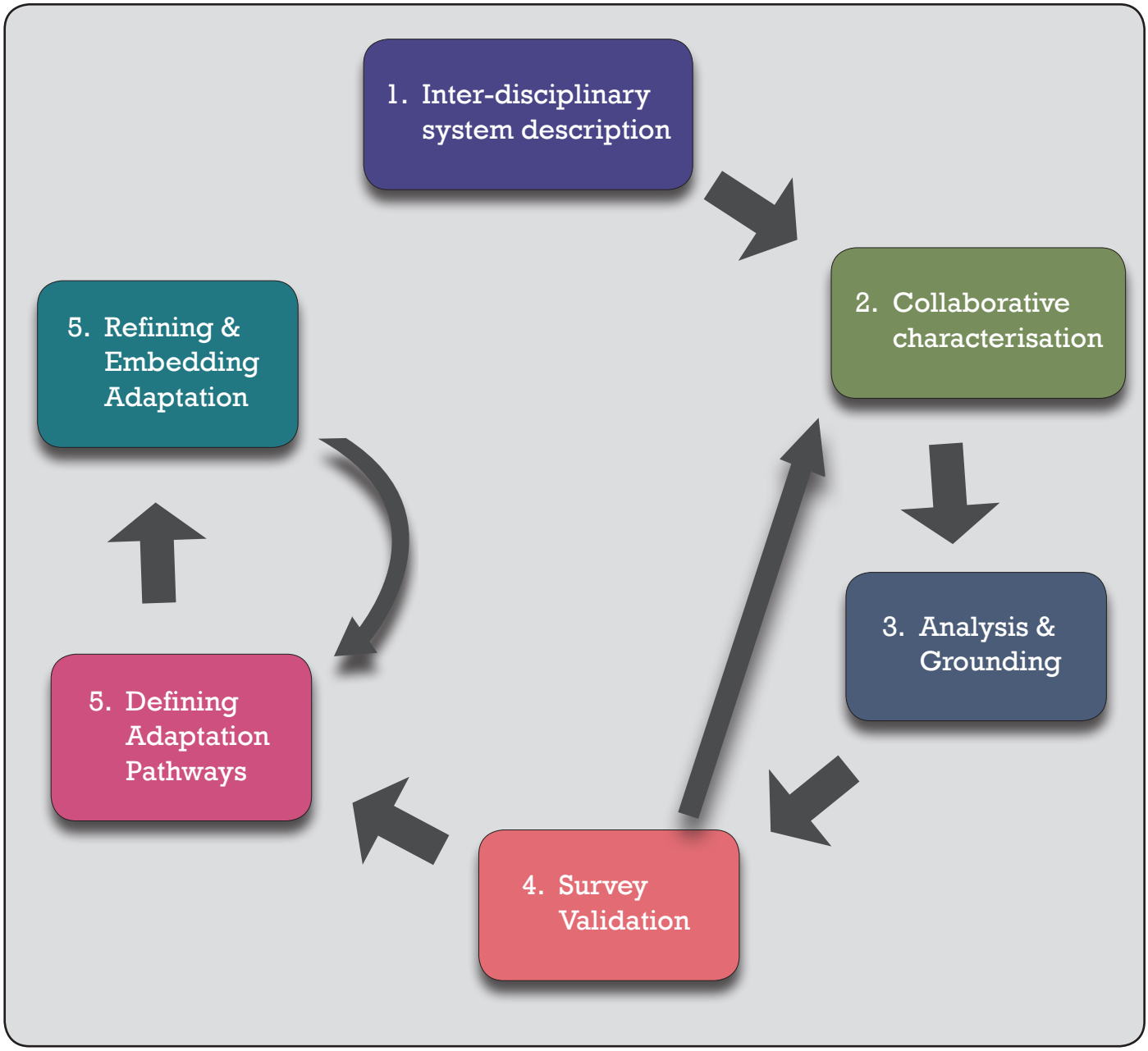


Figure 1. The diagnostic approach and six stages for developing adaptation pathways for a fishery

Stages of the diagnostic approach

1. Inter-disciplinary system description

OBJECTIVE

First-pass scoping of a specific fishery social-ecological system.

RATIONALE

1. Identifies key variables (see Table 2) which are crucial to:
   - adaptation; and
   - engaging relevant networks of people.
2. Builds inter-disciplinary capacity and social capital.

PROCESSES

1. Establish an inter-disciplinary team whose expertise include social, economic and biophysical research specific to the system.
2. Collate and synthesise secondary social, economic and biophysical data and publications.
3. Identify and interview key informants to identify main variables that will enable and constrain adaptation.
4. Analyse results, being inclusive of different data and view points (using a rapid Delphi process or similar (Linstone and Turoff 1975)).

OUTPUTS

1. A preliminary description of the fishery social-ecological system and the settings which structure action within it.
2. Working hypotheses about:
   - the structure and function of the fishery;
   - key variables that are crucial to adaptation; and
   - appropriate forms of engagement.

EXAMPLE OF DATA/KNOWLEDGE GENERATED

The (Draft) Climate Change Vulnerability Assessment for Four Key Commercial Fisheries in South-East Australia included desktop analysis of the main ecological impacts of climate change, and key social and economic components of the snapper, abalone, rock lobster and blue grenadier fisheries. The analysis included a description of the management systems and governance across the jurisdictions to underpin the scenario development and social risk assessment. This provides an one-stop overview of each fishery system in an accessible format to begin discussion about entry points for adaptation.

Scope your system, set the scene & build the team

Credit: Institute for Marine & Antarctic Studies, UTAS

2. Collaborative characterisation

OBJECTIVE

1. Work collectively with fishery stakeholders to characterise system change and key sources of variability.
2. Determine the relative influence of variables important to adaptation.

RATIONALE

Deliberative process to characterise the fishery social-ecological system begins to embed adaptation planning.

Ensures values, assumptions and divergent positions are made apparent.

PROCESSES

Workshop #1, at which the following steps are undertaken collectively:

1. highlight contemporary and potential system changes, risks, opportunities and uncertainties associated with climate variability and other major drivers within fishery social-ecological system;
2. identify values and assumptions and divergent positions among stakeholders;
3. disaggregate the social-ecological system to highlight 1st and 2nd order variables that constrain and enable adaptation (see Table 2 for examples); and
4. rate the relative influence of these variables in terms of how they constrain and enable adaptation, and rate the degree to which each variable is an internal (changeable) or an external (unchangeable) driver.

Note that ratings may differ significantly between stakeholders. Divergence in views is itself a second order variable that may overrule others and disable collective action (see U6 and U7, page 18). Using Radio frequency voting systems enables such divergent views to be detected early on in the process by the research team and collectively discussed in relation to potential interventions for adaptation.

OUTPUTS

Workshop report outlining:

1. current and potential system changes, risks, opportunities and uncertainties within fishery social-ecological system;
2. differences in mental models and perspectives, values and assumptions; and
3. 1st and 2nd order variables and preliminary ratings of their importance, noting the level of divergence and consensus.

EXAMPLE OF DATA/KNOWLEDGE GENERATED

The East Coast Tasmanian Rock Lobster Fishery Vulnerability Assessment 2009 investigated the connections between variables expected to alter

with climate change (such as temperature and currents), with the biology of lobsters and the manner in which they are harvested (eg, catch composition and catch rates). Using this information, the existing stock assessment model was modified to project forward and evaluate the likely exploitable biomass and egg production levels for two climate change scenarios. The next step would be to use these understandings along with those form Stage 1 to characterise the system drivers collaboratively, thereby beginning to define the most appropriate points of intervention.

Credit: Tasmanian Seafood Industry Council

What do we know & not know, & what matters for climate adaptation?

3. Analysis and Grounding

OBJECTIVE

1. Identify and clarify the state of current knowledge in relation to uncertainties and divergent perspectives of participants about the constraints and enablers of adaptation within the fishery social-ecological system.
2. Typify the fishery social-ecological system in terms of constraints and enablers of adaptation. Include differing views.

RATIONALE

Common ground and differences in mental models and perspectives are noted and clarified, but there is no attempt here to reach consensus at this stage.

PROCESSES

Research team to:

1. address key concerns raised in workshop #1, through desktop research and/or more targeted empirical research; and
2. clarify the various characteristics of the fishery social-ecological system deemed influential and rated as important in workshop #1 in terms of how they constrain and enable adaptive capacity.

OUTPUTS

Short report outlining:

1. state of current knowledge of constraints and enablers of adaptation within the fishery social-ecological system;
2. key contested and consensual statements; and
3. important 2nd and 3rd order variables (noting that 3rd order variables would be defined by stakeholders as required).

EXAMPLE OF DATA/KNOWLEDGE GENERATED

The (Draft) Climate Change Vulnerability Assessment for Four Key Commercial Fisheries in South-East Australia used stakeholder workshops to examine the results of desk-top analysis and to collate and incorporate participants' observations of oceanographic, ecosystem or fishery changes as well as major stressors for four key commercial fisheries in South-East Australia. The proposed approach would use interdisciplinary research to find out more about the key issues raised in stages 1 and 2.

What have we learned about what enables and constrains adaptation?

Credit: Tasmanian Seafood Industry Council

4. Survey Validation

OBJECTIVE

1. Validate levels of agreement with key contested and consensual statements.
2. Determine the relative importance of 2nd and 3rd order variables.

RATIONALE

Revise or re-affirm levels of agreement or disagreement with key contested and consensual statements and relative importance of variables.

PROCESSES

1. Survey fishers and other key stakeholders outside workshop setting, using a computer-assisted telephone interview (CATI).
2. Use the survey instrument to:
   - measure levels of agreement with key contested and consensual statements that resolve from the workshop process; and
   - determine the relative importance of 2nd and 3rd order variables identified as important in the workshop process.

OUTPUTS

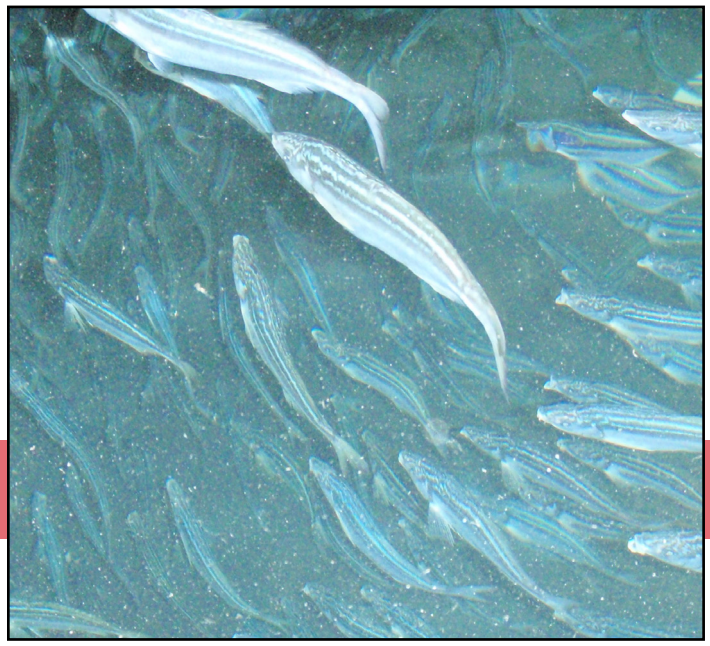
Report of survey results and analysis, including:

1. levels of agreement with key contested and consensual statements; and
2. the relative importance of 2nd and 3rd order variables.

EXAMPLE OF DATA/KNOWLEDGE GENERATED

The East Coast Tasmanian Rock Lobster Fishery Vulnerability Assessment 2009 included a risk perception study (workshop plus in-depth key informant interviews) which identified key constraining or influential variables affecting autonomous adaptation of fishers and the vulnerability of the fishery. The sort of approach we suggest can link such detailed information from group processes with broader perspectives and concerns of a larger groups or population.

Do we agree?



Credit: Tasmanian Seafood Industry Council

5. Defining Adaptation Pathways

OBJECTIVE

1. Develop a clear depiction of adaptive capacity within the fishery social-ecological system.
2. Develop workable adaptation pathways that are broadly agreed upon by participants.

RATIONALE

Collaborative process ensures proposed adaptation pathways are workable and can be embedded.

PROCESSES

Workshop #2, the stages of which include:

1. re-visit and discuss the analysis from previous stages; or
2. collaboratively define context appropriate adaptation pathways (using real options analysis or Deliberative Multi-Criteria Evaluation, see Fenichel et al. (2008) and Leung (2006) for more information about these techniques) as follows:
   - detail ways of addressing the key constraining variables and enhancing enabling variables;
   - processes and protocols for embedding adaptation in management, and for monitoring and evaluation of adaptive capacity and pathway development; and
3. set up a collaborative working group to begin to embed the adaptation pathways into the fishery.

OUTPUTS

Workshop #2 report and working group established.

EXAMPLE OF DATA/KNOWLEDGE GENERATED

The (Draft) Climate Change Vulnerability Assessment for Four Key Commercial Fisheries in South-East Australia used 3 approaches:

1. Governance benchmarking for effective fisheries management (stakeholder workshop)
2. Development of conceptual scenarios to identify adaptation options and barriers (stakeholder workshop)
3. Social risk analysis (desk-top)

These processes could be made more robust through collaborative planning processes such as those proposed in this user guide.

How do we enable adaption?
What are workable ways to adapt?

Credit: Institute for Marine & Antarctic Studies, UTAS

6. Refining and Embedding Adaption

OBJECTIVE

1. Refine adaptation pathways for developing adaptive capacity.
2. Identify processes and mechanisms for embedding these in structures and processes of governance, management, industry and among other stakeholder groups.

RATIONALE

Deliberative process led by a legitimate, core group of stakeholders ensures that plans and programs are workable, and moves towards embedding them.

PROCESSES

1. Governance of the project passes from researchers to the collaborative working group
2. Researchers work in the service of the working group to develop ways of utilising the diagnostic variables (or proxies for them) in monitoring and evaluation of adaptation processes
3. Working group reports periodically to the larger group of workshop and survey participants to seek feedback.

OUTPUTS

Specific adaption plans and programs, including ways of utilising the diagnostic variables (or proxies for them) in monitoring and evaluation of adaptation processes.

EXAMPLE OF DATA/KNOWLEDGE GENERATED

The East Coast Tasmanian Rock Lobster Fishery Vulnerability Assessment 2009 made recommendations for formation and assessment of adaptation policy and strategies.

Rather than a vulnerability study making recommendations from outside of a management agency, the diagnostic approach aims to be owned by the management agency, such that adaptation becomes a normal part of ongoing planning and review of a fishery's performance.

How do we make adaptation happen?

Credit: Tasmanian Seafood Industry Council

Variables for Fisheries Systems

Fisheries are complex Social-Ecological Systems. The diagnostic framework for Social-Ecological Systems was developed by Elinor Ostrom (2007; 2009) for assessing systems of common-pool resources, including fisheries.

The framework (see Figure 2 below) includes suggested first order variables. First order variables are described in relation to fisheries (see Table 2, page 13).

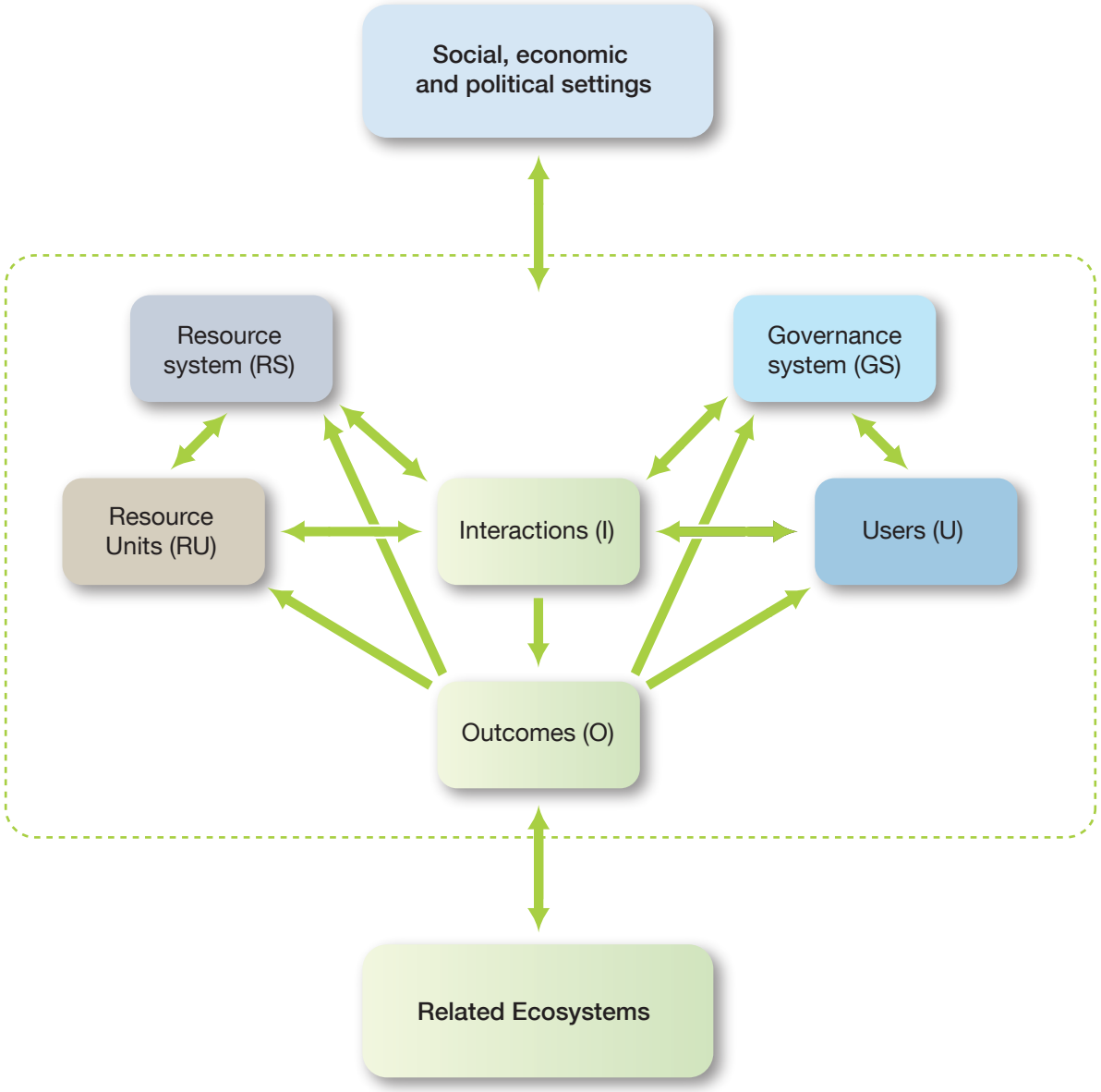


Figure 2. Conceptual Diagram of a Social-Ecological System (after Ostrom 2007; 2009)

Table 2. First order variables for analysing fisheries as Social-Ecological Systems (after Ostrom 2007; 2009)

First order Variables	**Description**
Social, Economic and Political Setting (S)	The external variables which structure action within a fishery but are not easy to change from within the system
Resource system (RS)	The physical and biological aspects and processes of the system that constrain or enable adaptation
Resource units (RU)	Characteristics of the resource itself (e.g. the particular fish species) that affect how adaptable the fishery is to change
Governance system (GS)	The formal and informal organizations, institutions, relationships, networks and rules that govern action within the system and thus affect adaptation and adaptive capacity
Users (U)	The traits of the resource users and other stakeholders, and interactions among them, including their use of technology, information and knowledge

Second order variables

The second order variables as suggested by Ostrom (2007; 2009) have been interpreted in the context of fisheries and climate change (see Table 3 below).

Table 3. Second order variables for analysing fisheries as Social-Ecological Systems (after Ostrom 2007; 2009)

Social, economic and political settings (S)

	Interpretation in the context of adaptation to climate change in fisheries systems
S1 Economic development	The state of economic development (e.g. emerging, growing, declining, immature and mature) of a region or social system can influence adaptive capacity. For instance, adaptive capacity may be higher under mature or emerging economies than immature or declining economies (Allison et al. 2009; Daw et al. 2009).
S2 Demographic trends	Indicator of socio-economic viability, and therefore broader adaptive capacity, of the social system surrounding a sector (Allison et al. 2009) and an indicator of long term changes in the system. Sub-variables include: ageing/dwindling population, outmigration, rapid population growth, employment trends.
S3 Political stability	The stability of government and the continuity of institutions, organisations and structures of government as well as policy setting and instruments may assist planned adaptation. Conversely, existing arrangements may constrain adaptation (Grafton 2010); climatic changes which cause resource rents to decrease have been found to reduce the likelihood of stable fishery agreements (Brandt and Kronbak 2010).
S4 Government settlement policies	The existence of government settlement policies in a coastal region can influence the ability of coastal communities to relocate inland (Brunner et al. 2004).
S5 Market incentives	The level of uptake of certification, labelling and other voluntary mechanisms can drive improved management, monitoring and innovation around environmental performance. Certification systems are potentially key instruments for adaptive change and may give market advantage (Gale and Haward 2011; Sainsbury 2010).
S6 Media organization	Strength of media to affect markets and political decisions can be both positive and negative for management of marine systems (i.e. can lead to rapid changes and imposition of politically tenable but unsustainable solutions) (Sullivan 1999; Aslin and Byron 2001). Can influence perceptions of climate change and the need to effect a response.

Second order variables

Resource System (RS)

	Interpretation in the context of adaptation to climate change in fisheries systems
RS1 Sector (e.g., water, forests, pasture, fish)	Sectors include: conservation management, capture fisheries (commercial, recreational and artisanal), aquaculture, and tourism.
RS2 Clarity of system boundaries	Spatial, ecological, social and organisational boundaries of systems may be well-defined or otherwise, as may access to the resource system and property rights of users. For instance, large open access systems may experience lack of clarity of communication between users (Fidelman et al. 2012).
RS3 Size of resource system	Spatial extent of the resource system negatively influences the capacity to manage the system which, in the marine context, relies on communication networks and technology to make the resource system visible, and therefore tractable, to managers and users. Climate-driven changes in larger marine resource systems, such as pelagic migratory fisheries involving multiple jurisdictions, are more difficult to monitor than in smaller, contained resource systems, such as embayment fisheries (Miller 2007).
RS4 Human-constructed facilities	Infrastructure and technology can affect efficiency of resource use. The availability and location of facilities may inhibit or enhance adaptive capacity of fishers to respond to range shifts in target species (Madin et al. 2012).
RS5 Productivity of system	Production over time will affect the size of a sector and therefore the degree to which livelihoods are dependent on the system. More productive systems will tend to have ability to recover from low to high abundance in a relatively short period of time, but people depending on the system may lack ability to adjust their business practice in the short run (Fréon et al. 2008). Seasonal and inter-annual variability in the productivity of a fishery will tend to result in diversification of livelihoods.
RS6 Equilibrium properties	Strength of equilibrium in the system (i.e. the breadth of a stability domain and strength of attractor) may be low for systems nearing thresholds of tolerance (coral reefs in relation to bleaching), high for those with wider tolerance ranges (pelagic migratory fishes) or somewhere in between. Difficult to determine especially where data is not available.
RS7 Predictability of system dynamics	Factors include the level of system complexity, visibility, and capacity in monitoring and understanding system dynamics which determine the ability to predict how climate change and extreme events may impact the system. Indicators of the system are essential to predictability. Marine systems have traditionally been lacking indicators because of the high cost or technical infeasibility of procuring indicators. Important to adaptation because it underpins scientific tractability of climate change (Nursey-Bray et al. 2012; Zhang et al. 2012; Miller et al. 2010).
RS9 Location	Location in relation to markets is important. Greater distances to markets means reduced options for finding alternative markets for new target species in response to climate-driven range shifts (Daw et al. 2009).

Resource Units (RU)

	Interpretation in the context of adaptation to climate change in fisheries systems
RU1 Resource unit mobility	Level of mobility of marine organisms is negatively related to the capacity to monitor and determine population dynamics. This has significant implications for identifying potential adaptation pathways for capture and aquaculture fisheries (de Young et al. 2008). For instance, the impact of climatic changes on farmed oysters is more easily predicted than the impact on migratory fish species, such as tuna, or species with complex life histories, such as lobster, which migrate over great distances and depths.
RU2 Growth or replacement rate	A major determinant of productivity and of the speed of recovery of a stock in response to overharvesting or following substantial shocks, such as extreme weather events, through replacement or recruitment into the fishery (Barange and Perry 2009)
RU3 Interaction among resource units	Climate-driven shifts in species distributions can cause profound changes in interactions between marine organisms, including increased competition or predation and changes to recruitment and dispersal processes. The types of interactions and relationships between species are a major determinant of the current and predicted effects of climatic change on ecological processes and regimes within a marine system (Johnson et al. 2011).
RU4 Economic value	High value resources may have more commercial interests and research funding involved in their management; therefore they may have greater adaptive capacity, although high value may provide incentive for overexploitation and increase vulnerability to climate change. Economic value might be a surrogate for other indicators depending on the scale and distribution.
RU5 Number of units	Population size of the fish stock is important because small population size (especially spawners) can reduce the size of future recruitment (recruitment overfishing) and make a fish stock vulnerable to environmental shocks (Sissenwine and Shepherd 1987).
RU6 Distinctive markings	Enables identification of ownership or accessibility and sometimes easier enforcement rules (e.g. distinct marking on juveniles / breeding individuals or use of tags in farmed abalone to distinguish from wild caught) (Chick 2010).
RU7 Spatial & temporal distribution	Highly variable distributions can mean that gradual changes in resources resulting from changing climatic conditions are hard to identify (a signal noise problem). For instance, longer term trends are difficult to identify in squid fisheries due to highly variable spatial and temporal distributions (Pecl et al. 2004).

Governance System (GS)

	Interpretation in the context of adaptation to climate change in fisheries systems
GS1 Government organizations	Capacity, influence and legitimacy of government agencies are critical to their ability to intervene in the functioning and adaptive capacity of systems, whether through enforcement of regulation, through support for market based initiatives, or by participating effectively in co-management arrangements (Gale and Haward 2011).
GS2 Non-government organizations	NGOs (inclusive of industry, community and environmental groups) can have credible influence in discussion about institutional change. The interests and value base of stakeholders or groups of stakeholders are sometimes at odds. For instance, NGOs, government agencies and resource users may all have different 'myths of nature' (Douglas 1985) and thus relate quite differently to information about marine biodiversity and resources.
GS3 Network structure	Social and supply chain linkages within a system can be described as network structures, either mathematically or in terms of linkages, social capital, collaboration, or trust. Operational (supply) networks are not so important but the networks between government, industry, research and environmental NGOs are important in the context of adaptive management of fisheries (Sandström and Rova 2010).
GS4 Property-rights systems	Systems of rights vary from open access common-pool resources to highly structured individual property rights (most commonly, individual quota management systems) which are closely monitored and highly regulated. The flexibility to adjust property rights is important for adaptation; where there are few fishers with tightly held property rights, these can have an enormous effect on how adaptation can proceed (Grafton 2010; Grafton et al. 2007).
GS5 Operational rules	Local informal rules, rather than rules enshrined in legislation and policy documents, can be important in shaping behaviour. If the divergence between these is significant then formal adaptation measures may be impeded (Wiber et al. 2010).
GS6 Collective-choice rules	Applies where fisheries are managed under collaborative or co-management arrangements.
GS7 Constitutional rules	Rules and regulations imposed through legislation and policy, for example, size limits, catch quotas, entry requirements. The extent to which the design of these rules either limits or facilitates adaptation cannot be underestimated (Daw et al. 2009).
GS8 Monitoring & sanctioning processes	The level and effectiveness of monitoring, enforcement and compliance of marine resource use in accordance with decision rules (Kuperan and Sutinen 1998) positively influences the extent to which management regimes can be adaptive.

Second order variables

Users (U)

	Interpretation in the context of adaptation to climate change in fisheries systems
U1 Number of users	More users (i.e. fishers) are often harder to organise, so the issues linking size of resource system and productivity are also affected by the number of users, but this issue remains contested (Ostrom 2005). Heterogeneity or homogeneity of users can also be important (i.e. the relative numbers of commercial and recreational fishers, or owner-operators and lease fishers) but this is a complicated variable, the effects of which also remain contested.
U2 Socioeconomic attributes of users	The relative poverty and livelihoods options of users can have substantial effects on their approach to fisheries resource use. Users with a high discount rate (for instance, where extreme poverty makes resource use obligatory to survival) will be less adaptive than those with a low discount rate (Cinner et al. 2011; Allison et al. 2009).
U3 History of use	Having a long history may lead to inflexibility but may also lead to greater ability to observe change. A short history of use may lead to more openness to innovation or may lead to inappropriate use. These more local variables may be more informative about adaptive capacity (Zhang et al. 2012; Nursey-Bray et al. 2012).
U4 Location	Location may be important to livelihood options where there is reliance on a particular species of fish, e.g., tuna (Allison and Horemans 2006).
U5 Leadership/ entrepreneurship	The ability to collaborate within sectors and between stakeholders often hinges on competent and committed leadership. Entrepreneurial leadership (Young 1991) within government and key stakeholder groups can help build capacity and foster adaptation.
U6 Norms/social capital	Changing fishing and management practices in response to climate-driven changes can be impeded by long-established norms. The strength of linkages and bonds within a group which reflect reciprocity and trust is fundamental to self-organisation and facilitates adaptation (Sandström and Rova 2010).
U7 Knowledge of SES/mental models	The level of understanding of dynamism, equilibrium and potential for change in the fishery SES It is critical that there is coherency of mental models among resource users and managers. In the context of climate change, adaptation may be impeded by lack of legitimacy of climate science and projected impacts on fish stocks (Nursey-Bray et al. 2012; Glenn et al. 2012).
U8 Importance of resource	Absolute dependence on a resource as a livelihood strategy can either limit or constrain adaptation. A variety of sub variables may reflect these constraints or limitations including: lack of skills to do other work, identity attachment to fishing as occupation, high/entry exit costs of alternate livelihood options (Allison and Horemans 2006).
U9 Technology used	Ability to take on new technologies and innovations may be important to applying a systems perspective, risk management and adaptation (Mahon et al. 2008). The ability to increase unrestricted effort using new technologies (effort creep) can increase risk of overexploitation and may reduce adaptive capacity.

Further Resources

Marine Adaptation Network

Visit the Marine Adaptation Network website for further resources: <http://www.nccarf.edu.au/marine>

The Marine Adaptation Network has a vision to build adaptive capacity and adaptive response strategies for the effective management of marine biodiversity and living marine resources under climate change. The Network aims to implement a strong interdisciplinary organisational framework to engage researchers, governments and industry in a way that will enhance adaptive capacity and reduce vulnerability of Australia's marine biodiversity and resources to climate change risks.

The Network is hosted within the Institute for Marine & Antarctic Studies at the University of Tasmania.

Marine Climate Change: Impacts and Adaptation Report Card 2012

Visit: <http://www.oceanclimatechange.org.au/content/index.php/2012/home/>

This 2012 Report Card demonstrates that climate change is having significant impacts on Australia's oceans and marine ecosystems.

Many new changes have been documented since the 2009 Report Card. There is now striking evidence of extensive southward movements of tropical fish and plankton species in southeast Australia, declines in abundance of temperate species, and the first signs of the effect of ocean acidification on marine species with shells. The report card highlights that the Australian science community is widely engaged in research, monitoring and observing programs to increase our understanding of climate change impacts and inform management. The comprehensive information shows that adaptation planning is already underway, from seasonal forecasts for fisheries and aquaculture, to climate-proofing of breeding sites for turtles and seabirds. The up-to-date information presented will assist ocean managers and policy makers to improve and justify actions to help our marine ecosystems adapt to the threat of climate change.

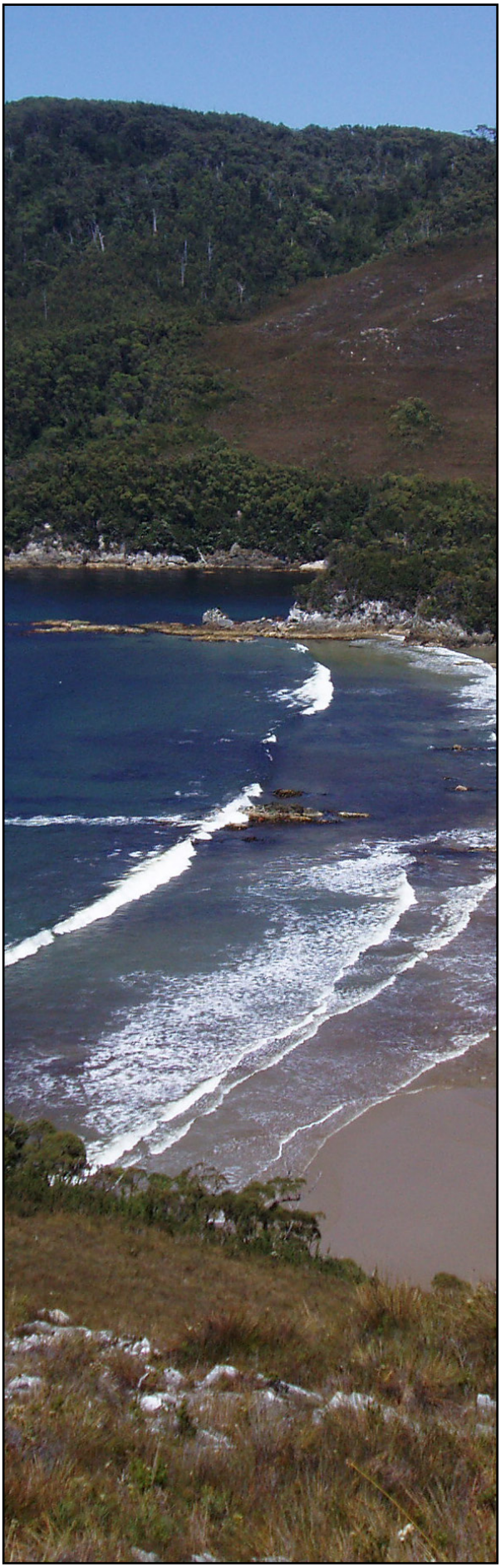
Markets Toolkit

Visit: <http://www.arnmbr.org/content/index.php/site/themes/category/markets_toolkit/>

This web-based toolkit provides decision-makers and researchers and interested members of the public with an overview of the ways in which economic (market-based) instruments and policy can be used in the marine environment to incentivise private sector adaptation to climate change.

weAdapt's Review of Adaptation Decision Tools

Visit: <http://weadapt.org/knowledge-base/adaptation-decision-making/adaptation-tools-review>



Credit: Tasmanian Seafood Industry Council

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Notes

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